Great Lakes Restoration Initiative
Interagency Agreement
Final Report – Executive Summary

Project Information and Results

A. Template Title: Assessing risk of Asian carp invasion and impacts on Great Lakes food webs and fisheries

B. Template Number: 2010-65-02

C. Template Lead Contact: Edward Rutherford, NOAA GLERL, Research Fishery Biologist, Ed.Rutherford@noaa.gov, 734-741-2118

D. Original Project Description: Bighead (*Hypophthalmichthys nobili*) and silver carp (*H. molitrix*) (collectively Asian carps) threaten to invade the Great Lakes and disrupt aquatic food webs and fisheries through their consumption of lower trophic levels. Preliminary studies suggest that Asian carps will have limited distribution and impacts on Great Lakes ecosystems, and these areas of potential impact include nearshore environments. However, impacts of Asian carps on aquatic food webs are potentially complex, and may require a spatially-explicit approach for looking at trophic interactions to assess both direct and indirect influences. Thus, we propose using two bioenergetics based modeling frameworks: 1) an individual-based community model of Asian carps and selected key species in nearshore and offshore environments; and 2) a spatially-explicit food web model of Asian carps impacts in nearshore and open-lake habitats of Lake Erie, Lake Huron and Lake Michigan. For both modeling approaches, we will model key fish species located in nearshore environments (i.e., Walleye, Yellow Perch, Alewife, Gizzard Shad, and Emerald Shiner) and selected key fish species found in offshore environments (i.e., Lake Trout, Lake Whitefish, Rainbow Smelt, Chinook Salmon, Deepwater Sculpin). To complement our work, we proposed to translate several papers on Asian carps from the Chinese literature into English in order to make them available for our modeling analysis and to other scientists. The goal of this modeling framework is to assess the ability of Bighead and Silver carps to survive and grow in Lakes Michigan, Huron, and Erie; and to determine the potential impacts of Asian carps on population dynamics and biomass of important native and state-managed fishes.

E. Project Results: Dr. Lori Ivan developed an individual based model (IBM) of Bigheaded carps (Bighead Carp, Silver Carp) and 4 selected fishes (Walleye, Yellow Perch, Rainbow Smelt, Round Goby) and their prey (Dreissena mussel, Detritus, Phytoplankton, Zooplankton, Bythotrephes, Benthos, Prey Fish) in Saginaw Bay, Lake Huron (Figure 1). She calibrated the base model to approximate density, growth, survival, diet and prey densities of resident fish without Bigheaded carps. She then introduced Bigheaded carps into the calibrated model and

simulated introductions of small numbers of carp to determine the minimum number required to establish a viable population in Saginaw Bay. Ivan found that as few as 10 individuals of either Silver Carp or Bighead Carp were needed to establish a viable population assuming a high juvenile survival rate. Silver carp, but not Bighead carp, were able to establish a viable population assuming a low juvenile survival rate, similar to that of Walleye, another river spawner.

Ivan also ran simulations to determine effects of Bigheaded carp on the resident fish community. The results again depended on assumptions of carp juvenile survival rate. Assuming a high juvenile survival rate, Bigheaded carp would reach densities exceeding 25 g/m^2, a density that caused declines in plankton and Rainbow Smelt densities, but slight increases in adult Yellow Perch and Walleye densities and no effect on Round Goby (Figure 2). At low juvenile carp survival, she found Bigheaded carp would reach densities of approximately 3 g/m^2, a level lower than found for Bigheaded carp in Lake Erie. At densities of 3 g/m^2, Bigheaded carp were not found to negatively affect plankton densities or resident fishes.

Dr. Ivan set up the IBM model to simulate Bigheaded carp effects on the offshore food web in Lake Huron, and the nearshore and offshore food webs in Lake Michigan. Although Ivan left in early 2015 to take another position, other project members are continuing the model work and will complete simulations for the other lakes. Ivan and others are writing up results for Saginaw Bay for a peer-reviewed manuscript.

Dr. Hongyan Zhang developed the Atlantis Ecosystem Model for Lake Michigan and Lake Erie, and aquired the necessary input data for the Atlantis_Lake Huron model. She calibrated the Lake Michigan Atlantis model to data from 1994-2014, then ran baseline simulations to simulate food web dynamics without Bigheaded carp present. The model results indicated that Asian carp introduction to Lake Michigan would have minimal effects on the Lake Michigan food web, causing less than a 20% decline in most planktivorous or piscivorous species. If Pacific salmonids were allowed to feed on Asian carp, the Asian carp population size and its effect on food web groups were projected to be even smaller (<10%). These model results are consistent with recently completed simulations of Asian carp introduction on Lake Michigan using the Ecopath with Ecosim model framework (Rutherford and Zhang, unpublished data), which also suggest Asian carp will have no substantive effect on the Lake Michigan food web. Zhang and others are writing up the results for a peer-reviewed manuscript.

Dr. Zhang also reviewed the Chinese literature to extract information needed to best simulate population dynamics of Bighead and Silver Carp. She read 27 journal articles written in Chinese and an additional 26 articles in English to find important information on Asian carp environmental tolerances and preferences, reproduction, feeding, diet, growth, survival, and effects on plankton biomass. These data were used to derive input parameters or model calibration values for the IBM and Atlantis Models.

F. Results Related to GLRI Action Plan Measures (if applicable):

Invasive Species

"Number of tributary miles protected by GLRI-funded projects"

"Number of aquatic/terrestrial acres controlled by GLRI-funded projects"

This project contributed to Army Corps of Engineers GLMRIS study and evaluation of the proposed Brandon Road Barrier by providing information needed to assess the ecological and economic impacts of Bighead and Silver Carp in the Great Lakes.

G. Funding resulted in the following accomplishments over the project period:

- Gave 11 presentations of model results at national and international meetings of Great Lakes managers and researchers including International Association of Great Lakes Research meetings in 2012, 2013, and 2015; American Fisheries Society meetings in 2012, 2014; American Society for Limnology and Oceanography meetings in 2012 and 2013; Joint Aquatic Sciences Meeting in 2014, and the Mississippi Yangtze River Basin Synthesis meeting in 2015.
- Developed and documented methods for Atlantis Ecosystem models for 2 Great Lakes and for the IBM for 1 Great Lakes. Ran simulations of Bigheaded carp effects on the Lake Michigan food web and on a nearshore fish community in Lake Huron.
- Manuscripts reporting results of model simulations are being prepared for submission to peer reviewed journals.

If applicable, include a short Project Highlight Story: N/A

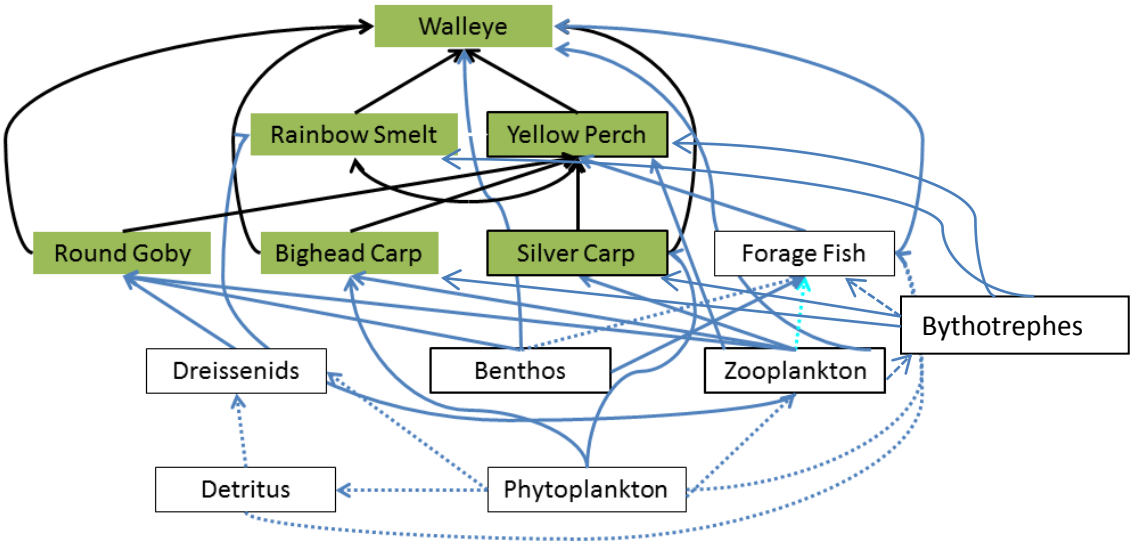

Figure 1. Food web diagram of Bighead and Silver Carp potential interactions with key resident species simulated using an individual-based, bioenergetics model of Saginaw Bay, Lake Huron. Green boxes show fishes tracked as individuals with clear boxes are tracked as uniform biomass pools. Black lines show interactions among individuals. Solid blue lines show interactions of individuals and biomass pools. Dotted blue lines show interactions among prey pools.

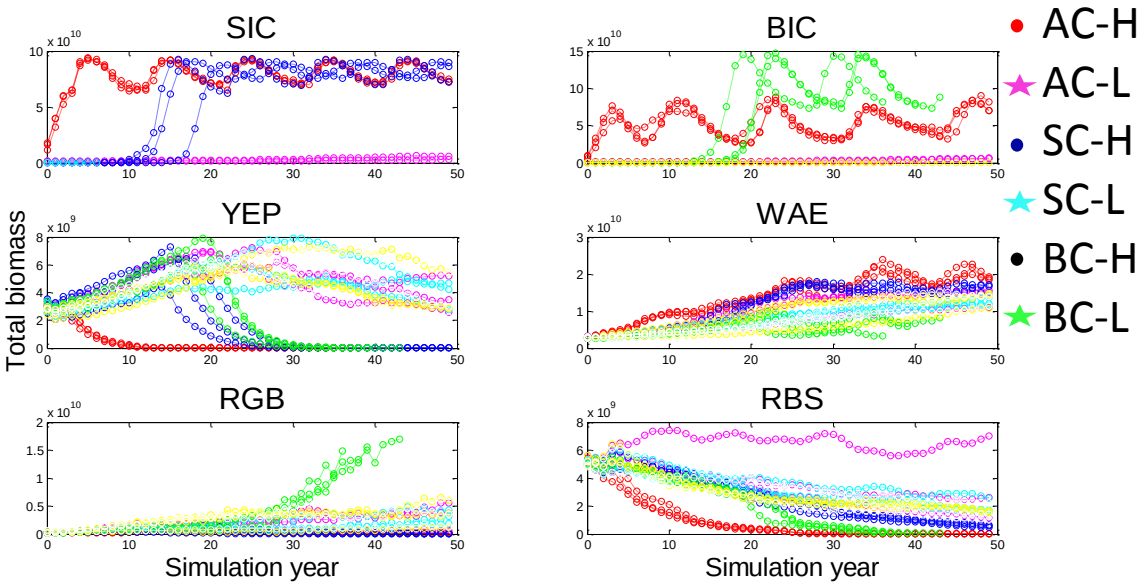

Figure 2. Individual-based model simulations of Bighead 'BIC' and Silver Carp 'SIC' biomass (gm) and their effects on resident fish species biomass in Saginaw Bay, Lake Huron. Resident species include Yellow Perch ('YEP'), Walleye ('WAE'), Round Goby ('RGB'), and Rainbow Smelt ('RBS'). Three replicate model simulations were run for each scenario for 50 years. Scenarios include a) both Bighead and Silver Carp have high juvenile survival 'AC-H'; both Bighead and Silver Carp have low juvenile survival 'AC-L'; Silver Carp has high juvenile survival 'SC-H'; Silver Carp has low juvenile survival 'SC-L'; Bighead Carp has high juvenile survival 'BC-H'; Bighead Carp has low juvenile survival 'BC-L'.